

WHITE PAPER

# Generate Transistor Curves with a Power Supply

When your lab lacks a dedicated transistor curve tracer use a power supply instead. A bench power supply with multiple outputs can generate a set of transistor curves for a metal-oxide-semiconductor field-effect transistor (MOSFET). A MOSFET is a field-effect transistor (FET) used for switching signals in electronic devices. A power supply with two positive outputs can test an N-channel FET, such as the popular 2N7000. An alternative is the BS170 N-channel MOSFET as it is very similar but has a higher drain current making it a more robust choice.



A power supply with multiple outputs can generate a gate voltage while powering the drain. The EDU36311A triple-output power supply's isolated outputs provide both a positive and negative gate voltage.



Accurately measuring the small drain currents requires short wires and minimal connections. Attaching short wires directly from the transistor to the power supply eliminates all unnecessary connections. Using sockets and breadboards can introduce significant errors. In Figure 1 most of the current flows from output 1 to the drain (D) and through the source (S) and back to output 1.

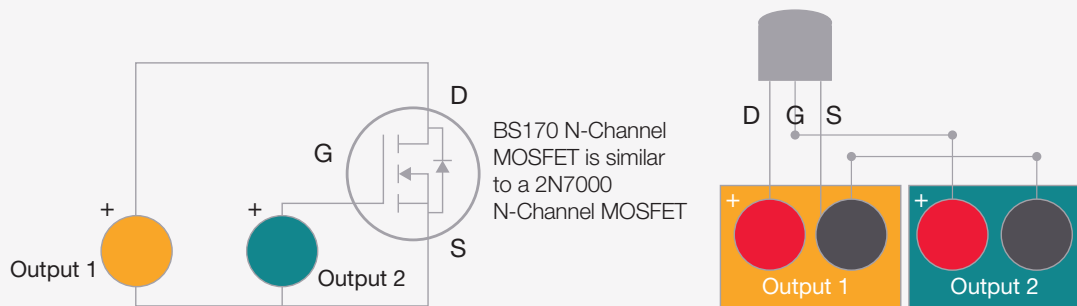


Figure 1. Connecting the transistor to the power supply

## Triple-output power supply

Keysight's EDU36311A triple-output power supply can source the drain voltage and current with its 6 V / 5 A output. The lower current 30 V / 1 A output drives the gate voltage. The isolated outputs can apply a positive or negative voltage to the gate. Reversing the polarity of output two applies a negative voltage to the gate. This process enables testing of the P-channel FETs because they require a negative gate voltage. Low noise outputs along with high-resolution readback can measure the milliamp drain currents of a FET. The power supply has several layers of device protection, and the most important is to set a current limit to safeguard the FET. You can connect your PC to the power supply with a USB or the LAN interface to automate the test.



Figure 2. EDU36311A triple-output power supply

You can use Microsoft Visual Basic for Applications (VBA) in Excel to automate the test and plot the results, as shown in Figure 3. The Keysight Connection Expert identifies the instrument's address and passes SCPI commands through its library.

Use the following steps to begin the process:

1. Use Connection Expert to find the address of the power supply you wish to use.
2. A red box highlights the instrument address, number of steps, and current limit, as shown in Figure 3.
3. Update the instrument address, the number of drain voltages to test, and the current limit for the drain current.
4. Edit the four gate voltages in row six and the drain-source voltages in column A.
5. In the orange box, initiate the controls in the middle of the page, starting at the top.
  - a. Open the connection
  - b. Start the measurement block. All the measurements in the table will update and the graph will also update based on the new data.
  - c. Close the connection

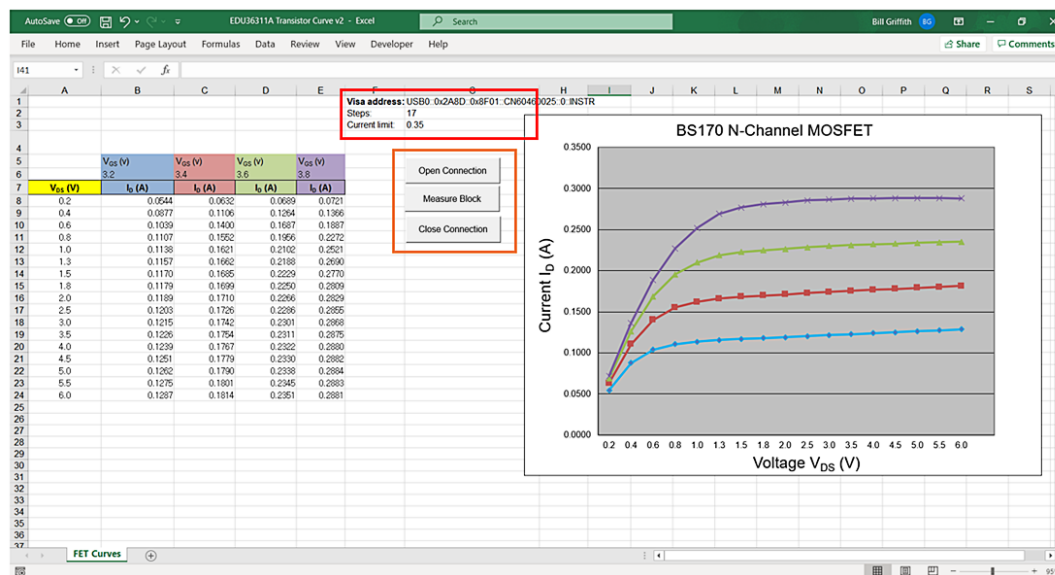
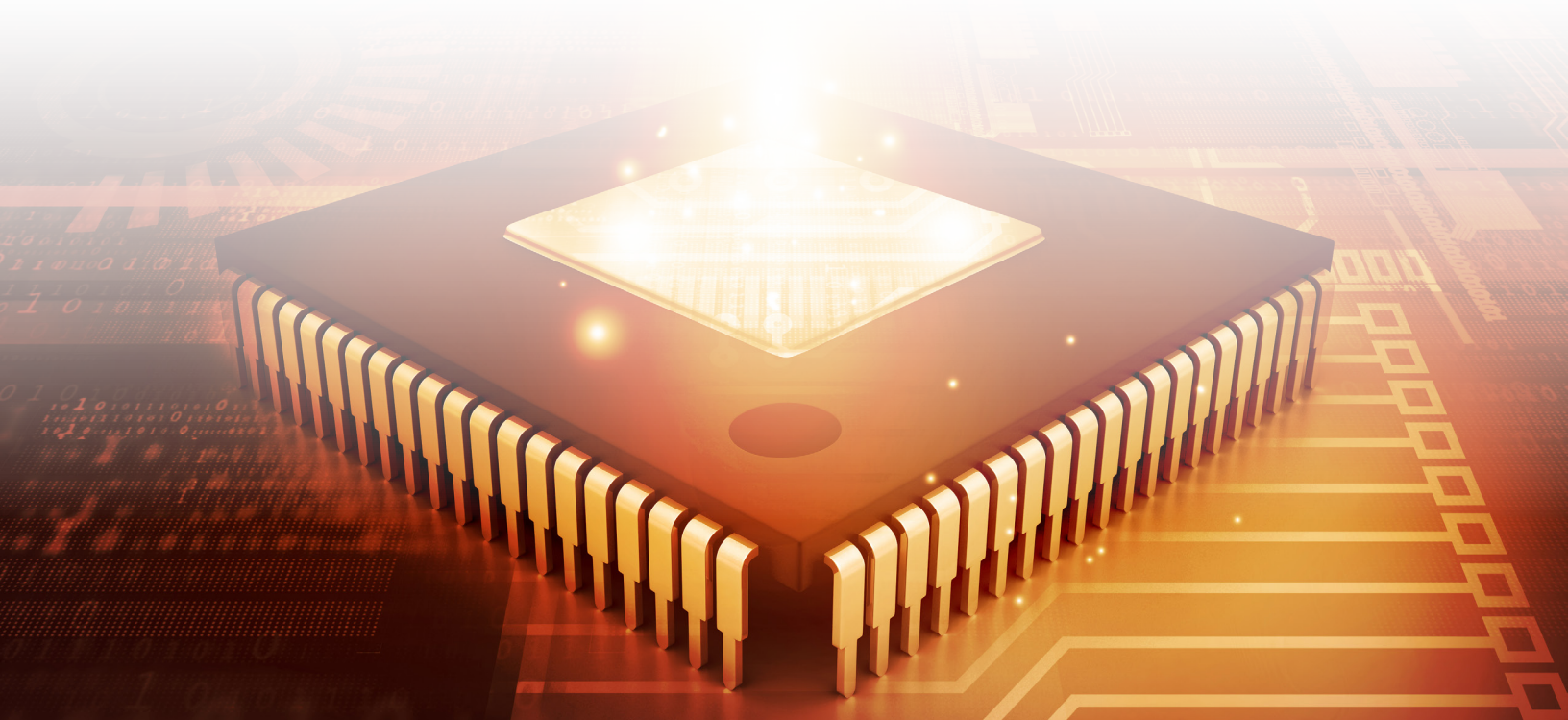


Figure 3. The Excel spreadsheet data results and chart of FET curves

The VBA program has five separate sections:

1. Declare global variables, including instrument IO and calls to the Keysight IO libraries.
2. Subroutine to open an IO connection to the instrument. The open connection button calls the routine, it uses the instrument address in cell G1.
3. Subroutine called by the measure block button. The routine sets up the power supply and updates all of the measurements in the table. First the routine initializes the power supply and uses a nested loop to set the gate voltage and an inside loop to step through each drain-source voltage. For each drain-source-voltage, the power supply returns a current measurement and updates the table with the measurement.
4. A function to create a delay allowing the transistor to settle before measuring the current.
5. Close the instrument's IO connection.



## Example program

----- Section 1 -----

### Option Explicit

```
Dim ioMgr As VisaComLib.ResourceManager
Dim PwrSupply As VisaComLib.FormattedIO488
Dim instrQuery As String
Dim instrAddress As String
```

----- Section 2 -----

### Public Sub Initialize\_Click()

```
On Error GoTo ioError

instrAddress = Range("G1").Value
Set ioMgr = New VisaComLib.ResourceManager
Set PwrSupply = New VisaComLib.FormattedIO488
Set PwrSupply.IO = ioMgr.Open(instrAddress

Exit Sub

ioError:

MsgBox "An IO error occurred:" & vbCrLf & Err.Description
```

### End Sub

----- Section 3 -----

### Public Sub measblock\_Click()

```
Dim col As Integer
Dim count As Long
Dim startRow, endRow As Long
Dim row As Long
Dim rng As Range
Dim Current As Double
Dim Vg As Double
Dim currLimit As Double

count = Range("G2").Value
currLimit = Range("G3").Value
startRow = 8
endRow = startRow + count - 1
Set rng = Range("B" & startRow & ":E" & endRow) ' Clears cells for measurements
rng.ClearContents
```

With PwrSupply

```
.WriteString "*RST" ' Reset the power supply
.WriteString "*CLS" ' Clear registers
.WriteString "CURR " & Str$(currLimit) & ", (@1)" ' Set current limit
.WriteString "OUTP ON, (@1:2)" ' Turn on outputs
For col = 2 To 5
    Vg = Cells(startRow - 2, col) ' Get gate voltage from spreadsheet
    .WriteString "VOLT " & Str$(Vg) & ", (@2)" ' Set CH2 Voltage to drive Vgs

    For row = startRow To endRow
        .WriteString "INST CH1" ' Send following commands to CH1
        .WriteString "VOLT " & Str$(Cells(row, 1)) ' Set drain-source voltage
        delay 0.1 ' Add a delay in seconds

        .WriteString "MEAS:CURR?" ' Measure drain-source current
        Current = .ReadNumber
        Cells(row, col) = Current ' Add drain-source current to spreadsheet
```

```

        Next row
        Application.ScreenUpdating = True
        Next col
        .WriteString "OUTP OFF, (@1:2)"           ' Turn off power supply outputs

    End With

End Sub

''----- Section 4 -----

Private Function delay(delay_time As Single)

    Dim Finish As Single                        ' Creates a delay in seconds
    Finish = Timer + delay_time
    Do
    Loop Until Finish <= Timer

End Function

\----- Section 5 -----

Public Sub instrclose_Click()

    On Error GoTo ioError

    PwrSupply.IO.Close
    MsgBox "Connection Closed"

    Exit Sub

ioError:

    MsgBox "An IO error occurred:" & vbCrLf & Err.Description

End Sub

```

## Summary

Using VBA in Excel and Connection Expert is an easy way to start programming instruments. The built-in charts simplify data visualization, and using the default instrument settings reduce the number of SCPI commands sent to the EDU36311A power supply. The example for this application uses less than ten SCPI commands. You can add additional measurements to the program, including measuring the gate current or the MOSFET's on-resistance. You can also modify the program to perform other tasks.

For more information: [EDU36311A Smart Bench Essentials DC Power Supply](#)

Learn more at: [www.keysight.com](http://www.keysight.com)

For more information on Keysight Technologies' products, applications or services, please contact your local Keysight office. The complete list is available at: [www.keysight.com/find/contactus](http://www.keysight.com/find/contactus)

